Using Data Modeling at the Elementary Level to Make Sense of Doing Mathematics and Science

Marjorie Henningsen, Ed.D.
Head of School, Wellspring Learning Community, Beirut, Lebanon
marjh@wellspring.edu.lb
Nisreen Ibrahim
Classroom Teacher, Wellspring Learning Community, Beirut, Lebanon
nisreeni@wellspring.edu.lb

Absract

In this workshop, participants engaged with and reflected on authentic artifacts from data modeling projects related to the solar system and to deforestation that were completed by elementary students in grade 5 (average age 11). These authentic examples were used to ground a discussion of using a data modeling approach to help elementary students make sense of and meaningful integrated use of mathematics and science concepts and tools. School-based ways of helping teachers understand this approach in order to be able to use it in their classrooms were also discussed.

Introduction: What is data modeling and how can we use it with students?

For nearly twenty years now the field of mathematics education has placed a great emphasis on the importance of engaging children actively in doing mathematics (and using mathematics to make sense of science). One very promising approach that has arisen during the last few years is the *data modeling* approach (Lehrer & Schauble, 2000; 2002). In nutshell, such an approach involves conducting some pilot research in order to form a preliminary model that may be used to make predictions, designing systematic tests of the model that involve collecting, organizing and analyzing data, followed by a process of reflecting on whether the data support the model and revising or refining the model accordingly, thereby generating a new cycle of inquiry and experimentation.

Modeling approaches are grounded in the notion that the act of creating or inventing models, testing them, and refining them or adopting new models is akin to how real mathematicians and scientists create new knowledge in their disciplines (Gravemeijer, 1999; Izquierdo-Aymerich & Aduriz-Bravo, 2003). At the same time, many researchers also note that learners develop their understandings of concepts through continuous efforts to make sense using iterative cycles of testing and retesting mental models or ways of thinking to see how well the model represents realities we experience (Lesh & Harel, 2003). So this approach clearly resonates when thinking about how design mathematics and science experiences for students both in terms of affording conceptual development and also in terms of engaging students in authentic mathematical and scientific activity.

Our context and the examples we explored for this session

The school is located in the heart of Beirut, Lebanon. It is a new international school, currently beginning its third year and hosting classes for children from ages 3-13. The elementary and preschool classes follow the International Baccalaureate Primary Years Programme (IB-PYP, which places great emphasis on both integration of subject matter, concepts and skills, as well as the importance of student-driven inquiry. The school campus contains more green space than is typical of an urban school in Beirut and the campus has been designed to function as an extension of the traditional classroom. The school administration is highly supportive of teachers using a data modeling approach and is investing considerable resources into developing teachers' capacities to use it. The approach is viewed as completely

compatible with and supportive of student learning in the IB-PYP programme.
The two examples we looked at in the session were drawn from work completed by the grade 5 students (average age 11). The first example related to the Solar System. One group of students gathered data on the diameters of planets and distances from the sun. They selected a certain scale factor in order to create a scale model of the solar system. They reflected on how their model differs from what the scientific community tells us about the real solar system. Through that reflection they were able to pinpoint flaws in their model and also in their choice of the scale factor. They were then able to refine their model.
The second example is drawn from the students' work on a unit about the global problem of deforestation. The most concrete focus of the unit had to do with the cedar forest reserves in Lebanon. The students engaged in a variety of research activities, including a field visit to one of the cedar reserves, in order to gather data to help them understand the various physical, political, social and economic threats to the forest and to try to theorize sustainable models for solutions. The inquiry was guided primarily by students' own questions and they used a variety of mathematical ideas and tools to help them answer their questions.

Benefits and challenges of using modeling with children
It is often hard for teachers to imagine how they can use a modeling approach given all the traditional constraints and demands most are faced with such as the relative mismatch between the time they have and what they are expected to cover in the curriculum, lack of resources needed to engage in authentic hands-on investigations, and the demands of frequent or high stakes standardized testing. It is even more difficult to imagine using this approach at the elementary level because of the tendency to view younger children as unable to deal with complex reasoning and problem solving. In our view, however, it is not only possible to use a data modeling approach with children, it is essential and comes very naturally for children if they are truly engaged in trying to make sense of phenomena.

As a result of engaging in modeling processes, students can become critical assessors of their own questions and the questions of others, they can learn to be flexible when reasoning about data, they can reason about the effectiveness and necessity of various representations, they can make sense of mathematical ideas and tools in a meaningful context, and they can develop a strong sense of the nature of science. Put more simply, they can develop the tools they need to help them understand and explain "how the world works" and even invent ways to make it work better.
Helping teachers understand the approach
One of the challenges to using this approach in the classroom, aside from those mentioned earlier, is the extent to which teachers understand what the data modeling process could look like and to believe in its relevance to what they think students need to learn. They also need to believe that it's possible to do it in the context of their own school environment. In our school we have found some helpful tools and strategies for facing these challenges.
First, we have addressed the process of data modeling both implicitly and explicitly in our programme of professional development. A central tool we have used is the book, *Investigating real data in the classroom: Expanding children's understanding of math and science* (Lehrer & Schauble, 2002). The book describes the data modeling approach and illustrates it through a collection of classroom cases written by teachers for teachers. We have tried as much as possible to make use of these cases to help our teachers gain a better understanding of what an inquiry cycle might

look like or how it might play out in a real classroom, as well as to analyze the components of lessons and units in order to scaffold their ability to plan for inquiry. In both cases, the modeling approach in use was not the specific focus of professional development but was always present in the discussion because it was the backbone for each of the cases we used. Later we were able to revisit the same cases, but to specifically focus on understanding the nuts and bolts of using the modeling approach with students using the case contexts that were already deeply understood by the teachers.

Elsewhere, we tried whenever possible to use data modeling to solve real problems in the development of our curriculum in the school—and to make it explicit for teachers that we are doing so. For example, one of the long term aims of our school is to develop a strong bilingual program in English and Arabic. So early in the process of developing our language policy we asked teachers to keep logs of their instructional use of colloquial and formal Arabic outside of dedicated Arabic language instruction time. After 24 weeks of collecting these data, the data were compiled and summarized in order to be able to see patterns in the amount of time spent using Arabic outside of Arabic class along with the types of activity contexts in which it occurred. We used these patterns, along with our reading of the literature on bilingual instruction to construct a plan (or model) for how Arabic could be used across all grade levels and how that use should change from one grade level to the next. The data and the model were presented to teachers and teachers were given language use targets and strategies to pilot during the final instruction unit of the year. In those meetings the process was explained to teachers as an example of data modeling in real life. Data from the pilot work were then used to refine the model and pinpoint better targets and expectations for the upcoming school year.

Concluding discussion

In the concluding discussion, the hallmark features of the data modeling approach were highlighted and summarized with an emphasis on how student inquiry into mathematics and science was supported using this approach. Participants were also asked to share examples from their own experience as applicable. From our perspective, the most important outcome of the session was for all participants to appreciate the power and potential of using such an approach with young children in order to expand their understanding of what it means to do math and science in the world.

References

Gravemeijer, K. (1999). How emergent models may foster the constitution of formal mathematics. *Mathematical Thinking and Learning, 1(2*), 155-177.

Izquierdo-Aymerich, M. & Aduriz-Bravo, A. (2003). Epistmelogical foundations of school science. *Science & Education, 1*2, 27-43.

Lehrer, R. & Schauble, L. (2002). *Investigating Real Data in the Classroom: Expanding Children's Understanding of Math and Science*. New York: Teachers College Press

Lehrer, R. & Schauble, L. (2000). Modeling in mathematics and science. In R. Glaser (Ed.), *Advances in Instructional Psychology: Educational Design and Cognitive Science* (Vol. 5), 101-160. Mahwah, NJ: Lawrence Erlbaum Associates

Lesh, R. & Harel, G. (2003). Problem solving, modeling, and local conceptual development, Mathematical Thinking and Learning, 5(2&3), 157-189.